Personal IoT: Ready or Not, South Africa?

Rukudzo Pamacheche[1,*]

[1] Department of Marketing Management, University of Johannesburg, Johannesburg, South Africa, Orcid: 0000-0003-0936-9384

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Abstract
The Internet of Things (IoT) paradigm represents a significant shift in consumer behaviour as users adapt to more convenient processes, thanks to the advent of industry 4.0 and growing digital transformation in South Africa. IoT is no longer restricted to workplace environments and is available for consumers to use for personal gains. This motivated the correlation study to develop a conceptual model to test the relationships between consumer optimism, innovativeness, discomfort and insecurity of the technology readiness index (TRI) and attitudes and adoption intention of new personal IoT technology. Cross-sectional quantitative data was collected on an online questionnaire completed by 178 respondents and analysed using PLS-based structural equation modeling. Findings confirm that optimism and innovativeness are motivators, increasing the degree of readiness for the IoT revolution. Conversely, insecurity and discomfort are inhibitors of adoption, revealing lags in readiness in terms of those constructs. Although the study was limited to four TRI constructs, it contributes insights about insecurity and discomfort attributes that need to be addressed to improve consumer readiness, based on a tested model. There are implications for IoT technology designers, standards authorities and academics for more creative presentation and breadth in consumer behaviour aspects that affect IoT readiness.

[1]Corresponding Author

* E-mail address: rpamacheche@uj.ac.za

1. Introduction

1.1. Background

The emergence of Internet of things (IoT) has transformed the world into a hyper-connected society as the increased usage of the Internet continues to permeate day-to-day activities in the workplace and home (Khan & Javaid, 2022; Uwaoma et al., 2023). Hailed as one of the cornerstones of the fourth industrial revolution (4IR or industry 4.0) it is also a primary driving force in the creation of smarter cities and smarter homes greatly admired in developed digital economies for more intelligently planned urban areas with superior quality of life, more efficiently run services and sustainability (Bellini et al., 2022). IoT stems from the systematic and digital foundations of industry 3.0 that popularized the usage of the Internet in industry, partial automation in manufacturing (Loffler & Tschiesner, 2013), home-based Internet connectivity, personal computing and Internet-enabled mobile devices (Romero Dexeus, 2019).

Not only has the Internet become ubiquitous in people's everyday activities; for example, in autonomous and connected vehicles in transport systems, in smart home technologies like lighting, security and entertainment systems, as well as wearables, such as smartwatches and sensory bodysuits for health and fitness tracking (Manubabu et al., 2022; Poongodi et al., 2020). Researchers agree that it is also the mainstay for the inter-operability that enables hard and soft technology objects to communicate with one another (Reddy et al., 2021; Tran-Dang et al., 2020), thereby improving the speed, efficiency and functionality of products and services to satisfy consumers more efficiently.

IoT refers to the network of physical and non-physical "things" – devices, applications, software, small and large machinery and spaces – that are inter-connected with one another via the Internet (Khan & Javaid, 2022; Mouha, 2021). Equipped with embedded sensors and actuators, the prime capability of IoT is the interoperability of connected devices and/or technologies. This entails collecting data from the environment, transmitting and storing it in a cloud database and retrieving and initiating tasks based on pre-programmed triggers in the environment. As predicted by Loffler and Tschiesner (2013) and Corfe (2018), it takes advantage of the Internet as the vehicle of information communication technology systems (ICTS) to maximize the benefits that consumer derive from device interaction.

Beyond being an extension of the digital revolution, IoT significantly accelerates the wave of innovation and introduces new habits and rituals that can be observed as changes in consumer behaviour, qualifying it as a revolution for social development as well. Among many 4IR developments over the last decade, technology and automotive companies continue developing concepts, testing and rolling out of driverless vehicles and this points to a paradigm shift in the future of autonomous transportation systems that will be more available to individuals in developed regions (Bissell et al., 2020; Mercedes Benz Group, 2024; Reilhac et al., 2016; Tesla, 2024).

While the IoT revolution seems inevitable, there are contentions about the imminence of the 4IR wave of innovation, or lack thereof. Moll (2023) questions the ideological existence of a technological revolution to confirm the 4IR and suggests that, in the absence of characteristic features of speed, scope and systems impact that define 4IR, there is no industry 4.0. However, in view of the incremental development of innovation from industry 3.0, Lee and Lee (2021), among others, support the holistic view of a progressive approach to recognising IoT as a modern technological paradigm and fundamental feature of industry 4.0. Moreover, given the evidence of disruptive changes in consumer behaviour considering personal IoT usage (du Toit & Stimie, 2023; Manubabu et al., 2022; Tripathi et al., 2023), the adoption of personal IoT shows an upward trajectory. For this research, personal IoT refers to IoT targeted for consumers to purchase and use in their daily activities rather than for use in manufacturing or industry capacity. It is necessary to make this distinction as adoption outcomes tend to differ between the supply and demand sides on IoT.

1.2. IoT in South Africa

An overview of South Africa's context of IoT suggests that the proliferation of personal IoT is supported by expanding infrastructure development and public-private initiatives to provide a foundation for easier adoption of IoT and a very vibrant market. This is evidenced by the growth in consumer purchases and usage of personal IoT devices for smarter and more convenient modern living in urban areas. Based on the International Institute for Management Development's (IMD) smart city observatory report (IMD, 2024), Cape Town ranks third among Africa's smartest cities after Cairo and Algiers. South Africa is recognised among the continent's most developed economies and its prospect for developing smart cities in which consumers benefit from home-based IoT consumer services is also recognised in higher LSM areas like Waterfall City, while the national smart cities framework earmarks Durban, Lanseria and Mooikloof Mega City for this innovative transformation (du Toit & Stimie, 2023; Parliamentary Monitoring Group, 2023).

South Africa's IoT market is expected to experience a compounded annual growth rate of around 13% towards a US$ 12 billion market between 2024 and 2029, according to Modor Intelligence's (2024) forecasts. Consumer adoption of personal IoT in South Africa is supported by the upgraded infrastructure available to enable device connectivity, including, but not limited to 5G wireless coverage in homes (Rooyen, 2024) and the availability of consumer IoT devices for sale on the market. Among others, major market players like Microsoft Corporations, IBM and Google play a key role in technology development, training and supply to support the growing demand in the consumer market (Mordor Intelligence, 2024). Among many brands of personal IoT technologies, the Amazon Echo, Amazon's smart home system with Alexa artificial intelligence (AI) personal assistant, is one of the most popular IoT home automation technologies on the market that is changing how people interact with one another and their home appliances by instructing Alexa to carry out mundane chores and tasks (Christian, 2024; Smith, 2020). Table 1 provides other examples in the IoT context.

Table 1: Versions of IoT in context

Type	Definition	Literature consulted	Contextual applications
Industrial IoT: IIoT	Technological ecosystem comprising of sensors, networks, servers, autonomous machines that enhance operational efficiency.	Boyes et al (2018); Khan and Javaid (2022); Gosh et al. (2020)	Production site optimisation and safety refinement; assembly alignment and quality assessment automation and alerting.
Personal IoT	Integrated system of IoT technology in devices and applications marketed and targeted for consumers to purchase and use in their daily activities for personal gains.	Boyes et al. (2018); Chang and Chen (2021); Harkin et al. (2022)	Virtual assistant, atmospheric sensors, home security, autonomous private vehicles, health wearables. **Examples:** Amazon Echo, Alexa; Google Home Assistant; Deebot Robot Vacuum; Apple Watch;

1.3. Problem Statement

While ongoing research and global projections predict that IoT will thrive in South Africa as early as within the next five years (Mordor Intelligence, 2024), the reality of the phased diffusion of innovation cannot be ignored (Attie & Meyer-Waarden, 2022; Lu, 2021). So far, developmental research has focused on IoT applications at the manufacturing and industry levels (Khan & Javaid, 2022) and minor consideration has been made for IoT at the consumer level. This leaves a wide gap in research that needs to reflect the consumer lens on their readiness to adopt personal IoT. Typical of most industrial revolutions, the degree of penetration at the consumer level depends on the scale of diffusion at the industry level. Consumer readiness for personal IoT is crucial because it reflects the base of the population's preparedness and willingness to accept IoT as a personal innovation. Consequently, changes in consumer behaviour enable industry and manufacturer level IoT to penetrate the market and complete this aspect of the IoT revolution.

Personal IoT adoption is not fully fledged in South Africa for various reasons. Some of these include consumers' limited and unequal access to 5G or fixed fibre connectivity (Mordor Intelligence, 2024) and the relatively high price of data. Moreover, uncertainty about the personal evaluations of consumers regarding personal IoT needs to be addressed. Given the country's high level of economic and digital inequality, notions of consumer optimism about personal IoT, their innovativeness to conceive such innovations as well as concerns about anticipated discomfort of using personal IoT and security issues need to be clarified.

It is necessary to consider the personal evaluations of consumers at a personal level. The benefits of personal IoT are barely tapped in South Africa and understanding consumer readiness is necessary for industry players to gauge the potential reception of personal IoT technologies, proactively address consumer concerns and anticipate developmental problems with personal IoT before national roll-outs of personal IoT devices.

1.4. Research objectives

The purpose of the research is to determine consumer readiness for personal IoT by assessing the extent to which consumers intend to adopt a new personal IoT technology. TRI constructs of optimism, innovativeness, discomfort and security and planned behavioural variable attitude towards adoption are seen as predictors of this intention.

The research objectives of this study are to:

- Expound on TRI as a measure of preparedness to accept and adopt a new technology for personal use, vis-à-vis personal IoT.
- Determine the association between optimism, innovativeness, discomfort and security and consumer attitude towards adopting new IoT technology.
- Determine the association between attitude towards and adoption of new personal IoT and the intention to adopt the technology.

1.4.1.1. Layout of the paper

Henceforth, the paper is structured as follows:

Section 2: Literature Review discusses the conceptual framework of the paper, the TRI, from which the main constructs are drawn as well as the hypotheses. The constructs of interest are consumer optimism, innovativeness, discomfort and security surrounding new personal IoT. It also discusses consumer attitude towards adopting personal IoT and intention to adopt personal IoT as outcomes of the TRI.

Section 3: Research Methodology outlines the practical method followed to collect and analyse data for the study.

Section 4: Results and Findings displays the results of descriptive statistics and structural equation modelling (SEM) to quantify the relationships among the constructs and discuss the findings.

Section 5: Managerial Implications highlights implications for management, academy and policy decision-makers in light of the research. Finally, Section 6: Conclusions, limitations and future research consolidates the study and directs suggestions for further research to continue research knowledge development.

2. Literature Review

This literature review discusses the conceptual framework of the technology readiness index (TRI) that underpinned the study, explaining user optimism, innovativeness, discomfort and security as the main constructs of interest that determine users' attitude towards adopting personal IoT and, eventually, affecting user intention to adopt more personal IoT.

2.1. TRI

In the domain of new technology adoption, the TRI measures users' preparedness to accept new technologies and their personal interactivity with new technologies (Parasuraman & Colby, 2015) based on the new user's assessment of motivators and inhibitors of adopting the technology. Originally, conceptualised by Parasuraman (2000), it was underpinned by the need to understand "… people's propensity to embrace and use technologies for accomplishing goals in home life…" (2000, p. 308). Despite the presence of pre-existing technology acceptance and adoption theoretical frameworks, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) and the Technology Acceptance Model (TAM) (Davis, 1987), along with the subsequent revisions to the models, the latter models were based on adoption within workplace environments where users were required to adopt new technologies in their work rather than choose them independently for personal gain. The TAM framework geared towards the design features of technology systems while UTAUT prioritised the effects of technology performance. The TRI fulfils the need to focus more on intrinsic personal qualities of motivators (optimism and innovativeness) and inhibitors (discomfort and security) of technology interaction for personal goals, making it suitable for studying personal IoT.

2.1.1. Motivators: Optimism and Innovativeness

Under the TRI, optimism describes a user's positive perception of a technology based on the cognitive belief that it can enhance the life of the user, offering them control over the technology as well as its ability to be flexible and efficient for meeting daily goals and demands (Parasuraman & Colby, 2015). The motivation to view a new personal IoT object, such as smart home automation system, a health and fitness tracker body suit or driverless car, optimistically stems from the perceived benefits that each technology offers to improve the personal life of the user (Manubabu et al., 2022; Tripathi et al., 2023). Among others, this includes the consumer's evaluation of the capability of the personal IoT device to improve their quality of life, enable them to remain connected to their social networks and make them feel confident and empowered. Favourable evaluations of a new technology are more likely to lead to favourable attitude towards adopting new technologies. Therefore, a higher degree of optimism about a new personal IoT technology leads to a positive attitude toward adopting new personal IoT technology.

The second motivator, innovativeness refers to the propensity to lead problem-solving endeavours through creative, new and dynamic methods (Parasuraman & Colby, 2015) that, according to Drucker (2014) result in progressive and positive changes in economic and social status. Consumers with a pioneer orientation typically adopt new technologies early and are more willing to explore new methods of solving problems and embrace these more seamlessly, understanding the benefits of doing so (Somang et al., 2021). Chang and Chen (2021) observe this in adopting of smart shopping technology for personalised superior shopping experiences. This lends more understanding of the value of disruptive innovativeness that consumers are more apt to adopt new technology that lessens their burdens, even if it also overhauls previous behavioural patterns for more satisfying outcomes (Khan & Javaid, 2022; Truong et al., 2020).

As motivators of technology adoption, optimism and innovativeness offer benefits of convenience, faster and more efficient service delivery to satisfy consumers, which encourage more favourable affection to adopt (Chang & Chen, 2021; Parasuraman & Colby, 2015). As a result, the following hypotheses were posited:

H1: Consumer optimism relates positively with attitude to adopt new personal IoT technology

H2: Consumer innovativeness positively affects the attitude towards adopting new personal IoT technology.

2.1.2. Inhibitors: Discomfort and Insecurity

In the realm of consumer technology adoption, discomfort represents the user's unease with the outcomes of using a new technology and the negative belief and feeling directly associated with using a new technology (Parasuraman & Colby, 2015; Priporas et al., 2024). While new users should expect outcomes that they are not accustomed to, the discomfort manifests in the dissatisfying or underwhelming outcome of interacting with the new technology. Because new technology generally requires new learning and assistance, it is not uncommon for new users to feel like they are being taken advantage of during interactions with the technology, as noted by Marikyan et al (2023) in the study of dissatisfaction with smart home devices. Similarly, the lack of confidence that consumers feel due to their limited understanding and control over the technology exacerbates the problem of discomfort and increases consumer frustration, especially when they cannot resolve problems during failed encounters. This can lead some to withdraw from any new technology (Johnson et al., 2021).

Cyber security has become one of the most crucial elements to safeguard in the digital era. It spans data protection and prevention of data spillage or misuse of information in all processes carried out by users and the technology (Martinez et al., 2024). It also encompases national and universal regulations and legislation to protect the rights of people in general when sharing data with technology (Custers, 2022). It is ever-more important in the IoT paradigm as sensors and actuators collect personal and environmental information inputs to perform the desired pre-programmed services independent of the consumer (Bissell et al., 2020; Manubabu et al., 2022). IoT devices become live repositories of sensitive consumer information, making them vulnerable targets for soliciting and harvesting consumer data. Major concerns and scepticism with insecurity are rooted in mistrust of IoT devices, the manufacturers of the technologies or cloud servers' big data administrators. The leads some consumers to avoid IoT technology altogether out of fear of being "watched" by big brother or not provide personal information to IoT devices for safety reasons (Karale, 2021). Other concerns stem from the need to confirm online transactions through other physical means so ensure that they are valid. Such negative risk assessments and additional effort required to ensure confidence in online security measures and policies promote resistance against adoption and diminishes the desire and possibility of adopting personal IoT (Kim & Park, 2022).

Consumer discomfort and insecurity are regarded as inhibitors to technology adoption as they reflect a consumer's negative risk assessment of the outcomes of adopting new technology. As a result, the following hypotheses were postulated:

H3: There is a negative relationship between consumer discomfort and attitude to adopt new personal IoT devices

H4: Consumer insecurity negatively affects attitude to adopt new personal IoT technology

2.1.3. Attitude and Adoption Intention

Studying the affective and conative responses of consumers is necessary for determining the extent to which their evaluations of the TRI indicators translate to favourable dispositions to adopt new personal IoT technologies. Applying the theory of planned behaviour (TPB) (Ajzen, 1991; Pal et al., 2020), attitude towards adopting a new personal IoT device reflects the affective dispositional prediction of the behaviour to adopt the new technology based on desire. Similarly, intention to adopt new personal IoT represents the conative disposition described by Ajzen's (1991) TBP and Hsiao's (2020) study on cognitive, affective and conation model in Internet marketing. It is necessary to establish a willingness to embrace personal IoT as it is a determining factor in the actual adoption. Both attitude and intention represent directional outcomes of technology readiness and the proclivity to behave in the same direction of their intention or conviction. In this case, this is the attitude and intention to adopt a new IoT technology.

H5: Attitude towards adopting personal IoT has a positive relation to adoption intention

Table 2 summarises the operationalisation of optimism, innovativeness, discomfort, insecurity, attitude towards adoption and intention to adopt new personal IoT from the conceptual TRI and theoretical TPB frameworks for the purpose if this study.

Table 2: Operationalisation of constructs

Construct	Operationalisation	Framework and Sources
Optimism	Consumer's positive perception of personal IoT technology, believing that it improves their life in terms of control, flexibility and efficiency to meet personal goals.	TRI (Manubabu et al., 2022; Parasuraman, 2000; Parasuraman & Colby, 2015)
Innovativeness	The consumer's proclivity to be a creative thought leader seeking personal IoT technology to solve daily life problems.	TRI (Drucker, 2014; Parasuraman, 2000; Parasuraman & Colby, 2015)
Discomfort	The consumer's view of having lack of control over personal IoT technology and feeling overcome or devastated by it.	TRI (Marikyan et al., 2023; Parasuraman, 2000; Parasuraman & Colby, 2015; Priporas et al., 2024)
Security	The consumer's perceived mistrust of personal IoT technology rooted in skeptisism about its functionality, concerns about personal harm or lack of safety while using personal IoT technology.	TRI (Karale, 2021; Martinez et al., 2024; Parasuraman, 2000; Parasuraman & Colby, 2015)
Attitude towards adoption	Consumer's affective pre-disposition to adopt new personal IoT technology.	TPB (Ajzen, 1991; Pal et al., 2020)
Adoption intention	Consumer's conative disposition to adopt new personal IoT technology	TPB (Ajzen, 1991; Hsiao, 2020)

Source: Author's compilation (2024)

2.2. Conceptual model

The conceptual model for the research is presented in Figure 1, based on the hypotheses and operationalised constructs.

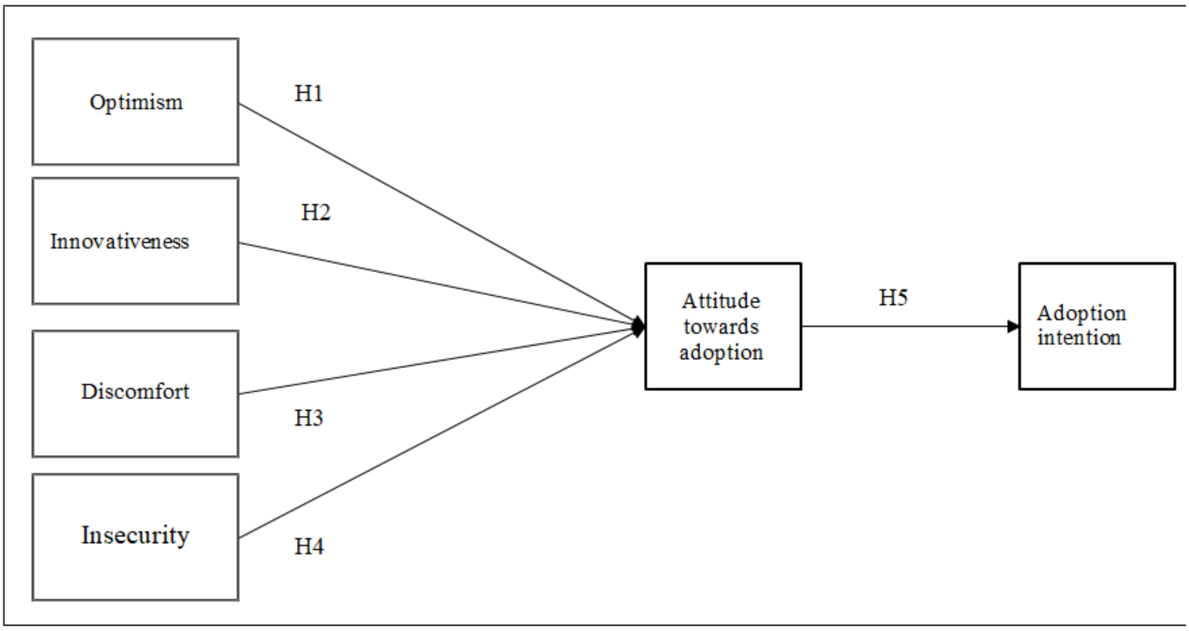

Figure 1: Conceptual model of technology readiness and dispositions to adopt new personal IoT technology

Source: Author's compilation (2024)

3. Research Methodology

3.1. Research survey and sampling

The research methodology of the cross-sectional study followed a survey strategy using a quantitative approach to collect data on an online self-administered questionnaire presented on a Google Form and shared with close contacts. The study employed a dual sampling strategy involving snowball and random sampling techniques to recruit and refer respondents to the survey. While snowballing is non-probabilistic, it was useful for identifying more respondents by referral, taking advantage of respondents' associations to boost the response rate for the survey (Bryman & Bell, 2015) and increase the probability of referrals to desirable candidates that are familiar with the subject area (Mweshi & Sakyi, 2020).

Sampling entailed inviting the researcher's close contacts to respond to the questionnaire by sharing the Google Form link on a social media account and encouraging them to make referrals by sharing the link with their contacts. Beyond close contacts, the researcher approached respondents living and working within Johannesburg metropolitan area at random, invited them to participate and make referrals to their contacts. The random selection of respondents was necessary to reduce the bias of snowballing due to the influence of respondents referring the survey to contacts with similar characteristics (Mweshi & Sakyi, 2020; Saunders et al., 2015). Respondents were screened to ensure they met the predetermined criteria of being familiar with at least one personal IoT technology, not limited to the examples that were provided on the questionnaire. This was necessary to ensure their suitability (Creswell & Creswell, 2018). The respondent profile is summarised in Table 3 under the Methodology section.

In addition to biographical information, the questionnaire required respondents to indicate their opinions regarding the following on a five point Likert scale:

- Optimism: optimism about a new personal IoT technology
- Innovativeness: innovativeness to use a new personal IoT technology
- Discomfort: discomfort associated with using a new personal IoT technology
- Insecurity: insecurity surrounding the use of a new personal IoT technology
- Attitude: their attitude towards adopting a new personal IoT technology, and
- Adoption intention: their intention to adopt a new personal IoT technology in the near future.

Items in each construct were measured on a five-point Likert scale with the indicators: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly disagree.

Sample data collected from 178 respondents residing in South Africa was analysed using partial least squares (PLS)-based structural equation model to determine the relationships among the constructs postulated in the hypotheses.

3.2. Ethics

The questionnaire underwent an independent ethical review process at the University of Johannesburg and was approved with ethical protocol reference number 2024SCiiS005. In line with the ethical standards of data collection, storage and use of information policies of the University, matters of respondent anonymity, confidentiality and data management were closely adhered to in the online data collection process and beyond.

4. Results and Findings

The summary statistics of the respondent profile is presented in Table 3, measurement model assessment results are summarised in Table 4 and major empirical results of relationships between constructs are presented in Table 5.

Table 3: Respondent profile

	N	**%**		**N**	**%**
Age group (yrs)			**Gender**		
18-27	16	9	Male	67	38
28-43	141	79	Female	93	52
44-59	21	12	N/A	18	10
	178	**100**		**178**	**100**

Field of expertise / education			
Engineering / built environment	62	35	
Computer science / Technology	53	30	
Commerce	37	21	
Health science / medicine	12	7	
Art	9	5	
Other	5	2	
	178	**100**	

The results of the study are most relevant to South African residents aged between 28 and 43 and who identify as either male or female. More than a third of the sample are occupied and/or qualified in the engineering and built environment field (35%), 30% in computer science and technology and 21% are based in commerce professions. Engineering and computer science professions are already exposed to industrial IoT technologies in their workspaces, thanks to rapid industrial developments in electrical, architectural, mining, construction and civil engineering (Ghosh et al., 2020; Khan & Javaid, 2022; Woodhead et al., 2018). This likely explains why they account for two thirds of the sample for responding to new personal IoT technology as their exposure increases their understanding and translation from industrial to personal IoT devices. It is surprising that health and medical science professionals only represent 7% of the sample, given that notable strides have been made in developing personal IoT devices for monitoring health and fitness, including wearables (Manubabu et al., 2022; Poongodi et al., 2020). Nonetheless, this may also be explained by the priority placed on IoT for health care rather than for personal gains. It is also important to note that the sample is not exhaustive in its scope, however, can be regarded as representable for the purposes of the study.

Inferential statistics comprised of the measurement model assessment to analyse and verify the reliability and validity of the constructs as well as hypothesis testing via on path analysis of the structural model. Accuracy analytics are summarised in Table 4 and the results of hypothesis testing are presented in Table 5.

Table 4: Accuracy analytics for measurement model

Variable	**Item**	**Factor loading**	**St. Deviation**	**α**	**CR**	**AVE**	**√AVE**
Optimism	OPT1	0.735	0.021	0.690	0.688	0.601	0.775
	OPT2	0.641	0.073				
	OPT3	0.633	0.091				
	OPT5	0.582	0.067				
Innovativeness	INV1	0.744	0.019	0.804	0.809	0.692	0.831
	INV2	0.961	0.043				
	INV3	0.802	0.018				
	INV4	0.899	0.041				
	INV5	0.783	0.084				

Discomfort	DCF1	0.587	0.109	0.729	0.711	0.624	0.789
	DCF2	0.814	0.012				
	DCF3	0.733	0.042				
	DCF4	0.768	0.081				
Insecurity	NSC1	0.745	0.094	0.650	0.639	0.599	0.773
	NSC2	0.689	0.035				
	NSC3	0.713	0.033				
	NSC5	0.690	0.099				
Attitude towards adoption	ATT1	0.770	0.037	0.721	0.704	0.661	0.813
	ATT3	0.719	0.044				
	ATT4	0.684	0.089				
	ATT5	0.700	0.084				
Adoption intention	INT1	0.632	0.055	0.620	0.609	0.574	0.757
	INT2	0.598	0.014				
	INT3	0.697	0.037				
	INT4	0.746	0.079				
α=Cronbach's alpha; CR=composite reliability; AVE=average variance extracted;							

Reliability and validity tests entailed retaining items that loaded successfully to achieve acceptable measurement model indicators. This also ensured that each construct was adequately represented by its collective items. Construct reliability was assessed using Cronbach's alpha and CR and all constructs returned indicators above 0.6, verifying reliability as recommended by Spitzer (1978) and Hair et al. (2017). Convergent validity was measured by the item factor loading (>0.5) and AVE (>0.5), according to Fornell and Larcker (1981) and Henseler et al. (2015). All the constructs successfully met the threshold for convergent validity with their retained items, proving that retained items converged with others each construct. Discriminant validity measured by comparing the √AVE with inter-construct correlations, assesses the extent to with each construct is distinct from others (Ab Hamid et al., 2017; Fornell & Larcker, 1981). Since all cross-loading on the diagonal were less than the √AVE for each construct, discriminant validity of each construct is confirmed.

The results of the hypothesis test (Table 5) show that all five hypotheses are accepted at $p<0.05$, $t>2.57$ significance thresholds for 99% confidence, as recommended by (Hair et al., 2017; Krommenhoek & Galpin, 2013). Given the standardised root mean square residual (SRMR≤0.08) and normed fit index (NFI≥0.9), the requirements for model fit are satisfied (Kline, 2011; Schumacker & Lomax, 2004).

Table 5: Hypothesis testing results

Hypotheses		β- coef	t-value	p-value	Effect size	Bias-corrected CI	Decision
H1	OPT → ATT	0.741	16.089	0.000	1.028	0.779	Accept
H2	INV → ATT	0.520	6.967	0.000	0.161	0.534	Accept

H3	DCF→ ATT	-0.230	4.450	0.000	0.079	0.421	Accept
H4	NSC →ATT	-0.351	4.098	0.000	0.088	0.414	Accept
H5	ATT → INT	0.311	5.180	0.000	0.106	0.461	Accept
SRMR=0.053; NFI=0.9 OPT=optimism; INV-innovativeness; DCF=discomfort; NSC=insecurity; ATT=attitude towards adoption; INT=adoption intention							

The model indicates the strongest relationship between consumer optimism and attitude towards adoption (β=0.741), reflecting consumer optimism as the strongest determinant of a positive attitude to adopt a new personal IoT device. Optimism is mostly attributed to respondents' expectation to tailor their lives to their desire and making home life more convenient. This is consistent with the theoretical understanding of the implications of users' optimistic views about IoT technology discussed by Chang and Chen (2021) regarding smart shopping experiences and Poongodi et al. (2020) regarding wearable health technology.

As confirmed, innovativeness proves to be a strong positive influencer of attitude to adopt a new personal IoT technology, with a strong positive path coefficient (β=0.520). This demonstrates that, despite relatively minor indication of being the first among their social circles to adopt new technology, respondents find smart IoT home technologies mentally stimulating, contributing majorly to their innovativeness. Consumer optimism about new personal IoT devices as well as their perception of their innovativeness are motivators leading to positive attitudes towards adopting new personal IoT technologies.

The model returned negative path coefficients between the inhibitors and attitude to adopt personal IoT. Insecurity recorded the stronger negative relationship (β=-0.35) compared to discomfort (β=-0.230). Respondent views of insecurity stemmed mostly from perceptions of potential misuse of personal information made available to IoT devices. This is crucial as it feeds concerns about transparency and ethical practices of managing sensitive consumer data that it recorded and stored on the device and cloud repository.

Adding to this, discomfort was attributed majorly to limited understanding of new personal IoT devices, which affects the control that consumers have over the technology when using it for personal gains. In accordance with ISO 21600, the international organisation for standardisation on technological products, devices should be accompanied by manuals documenting how it should be operated (ISO, 2019). Therefore, the problem may lie in the presentation of information in the manual, rooted in the use of palatable language for users as well as mode of presentation.

5. Managerial Implications

The research draws attention to the need for transparency about the ethical usage of IoT technology to assure consumers. The increasing relevance of IoT technology in the digital era raises concerns of IoT usage by consumers, calling for more responsible behaviour by industry and consumers. It is important for management and policy makers involved in the creation, selling and monitoring of personal IoT technology to consider social, legal and policy aspects through the consumer lens. Strong indicators of fear of IoT because of the privacy infringement call for more robust policies for handling consumer data made available through IoT. Therefore, industry leaders need to consider the design effects of personal IoT technologies and devices with responsibilities for ethical implementation of security protocols. Furthermore, the involvement of policymakers is necessary for ensuring adequate adherence to governance and policy frameworks that are available, aligned for managing and safeguarding user information.

Business leadership in marketing, design and management of personal IoT devices need to address the design and presentation concerns of personal IoT devices beyond the recommended ISO 21600:2019 and ISO 30162:2022. This is necessary to alleviate consumer discomfort and help to educate consumers about personal IoT functionality and its correct usage in more creative ways that are easier to understand. Management teams may consider insights from this research to guide decisions on actionable imperatives for improved IoT technology and device design as well as consumer relationships.

Theorists can expect to develop and test more composite and inclusive conceptual and theoretical frameworks with social constructs beyond the TRI adaptation used in this research. The relevance of technology readiness from the consumer lens should include external factors of consumer behaviour, such as culture, digital literacy, prior exposure to IoT in the workplace and value-based assessments of social-economic factors. Future trans-disciplinary research engaging marketing, business, sociology and information systems theorists is encouraged to contribute voices from the consumer lens to conceptual, theoretical and methodological research on personal IoT readiness.

6. Conclusions, Limitations and Future Research

To this end, the study examined the extent to which consumer optimism, innovativeness, discomfort and insecurity affect consumer attitudes to adopt new personal IoT technology as well as the adoption intention. The conceptual model was based on the TRI framework and dispositional outcomes of the theory of planned behaviour (TPB). The intention was to address the gap in research in personal IoT adoption at the consumer level as well as to gauge the level of readiness of consumers in South Africa, vis-à-vis the rapidly developing IoT revolution. Findings indicate that consumer optimism and innovativeness are indeed significant motivators for attitudes and adoption intention. On the other hand, findings also confirmed the negative effect of consumer discomfort and insecurity associated with new personal IoT technology.

Conceptually, the study was limited to the primary four indicators of the TRI and relied on respondents' evaluations of motivator and inhibitor factors to determine their readiness. The recommendation to academic researchers for future research is to incorporate more expansive social consumer factors that will influence consumer adoption of new personal IoT devices. Among others, these include culture, digital literacy, prior exposure to IoT and value-based assessments of social-economic factors. Methodically, in the spirit of IoT, researchers should motivate research strategies for capturing consumer data by observation, rather than by self-reporting surveys, to provide more reliable consumer.

The study highlights a number of implications for management teams in marketing, design and policy to address concerns about consumer insecurity and discomfort that present challenges to personal IoT technology adoption and consumer readiness. The implications include more creative approaches of presenting technology and device manuals as well as recommendations to ISO 21600:2019 and ISO 30162:2022 universal standard applications.

References

Ab Hamid, M. R., Sami, W., & Mohmad Sidek, M. H. (2017). Discriminant validity assessment: Use of Fornell & Larcker criterion versus HTMT criterion. *Journal of Physics: Conference Series*, *890*, 1–5. https://doi.org/10.1088/1742-6596/890/1/012163

Ajzen, I. (1991). The theory of planned behaviour. *Organisational Behaviour and Human Decision Processes*, *50*, 179–211.

Bissell, D., Birtchnell, T., Elliott, A., & Hsu, E. L. (2020). Autonomous automobilities: The social impacts of driverless vehicles. *Current Sociology*, *68*(1), 116–134. https://doi.org/10.1177/0011392118816743

Boyes, H., Hallaq, B., Cunningham, J., & Watson, T. (2018). The industrial internet of things (IIoT): An analysis framework. *Computers in Industry*, *101*, 1–12. https://doi.org/10.1016/j.compind.2018.04.015

Bryman, A., & Bell, E. (2015). *Business research methods* (4th ed.). Oxford University Press.

Chang, Y.-W., & Chen, J. (2021). What motivates customers to shop in smart shops? The impacts of smart technology and technology readiness. *Journal of Retailing and Consumer Services*, *58*, 102325. https://doi.org/10.1016/j.jretconser.2020.102325

Christian, C. (2024, January 11). IoT 2023 in review: The 10 most relevant IoT developments of the year. *IoT Analytics*. https://iot-analytics.com/iot-2023-in-review/

Custers, B. (2022). New digital rights: Imagining additional fundamental rights for the digital era. *Computer Law & Security Review*, *44*, 105636. https://doi.org/10.1016/j.clsr.2021.105636

Davis, F. D. (1987). *User acceptance of information systems: The technology acceptance model* (Working Paper #529; pp. 1–36). University of Michigan. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/35547/b1409190.0001.001.pdf

Drucker, P. (2014). *Innovation and Entrepreneurship*. Routledge. https://doi.org/10.4324/9781315747453

du Toit, B. R., & Stimie, J. E. (2023). Towards smart cities in South Africa: Evolution, definitions, and future cities. *South African Journal of Industrial Engineering*, *34*(1), 85–96. https://doi.org/10.7166/34-1-2839

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39–50. JSTOR. https://doi.org/10.2307/3151312

Ghosh, A., Edwards, D. J., & Hosseini, M. R. (2020). Patterns and trends in Internet of Things (IoT) research: Future applications in the construction industry. *Engineering, Construction and Architectural Management*, *28*(2), 457–481. https://doi.org/10.1108/ECAM-04-2020-0271

Hair, J. F., Hollingsworth, C. L., Randolph, A. B., & Chong, A. Y. (2017). An Updated and Expanded Assessment of PLS-SEM in Information Systems Research. *Industrial Management & Data Systems*, *117*(3), 442–458.

Harkin, D., Mann, M., & Warren, I. (2022). Consumer IoT and its under-regulation: Findings from an Australian study. *Policy & Internet*, *14*(1), 96–113. https://doi.org/10.1002/poi3.285

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hsiao, C.-C. (2020). Understanding content sharing on the internet: Test of a cognitive-affective-conative model. *Online Information Review*, *44*(7), 1289–1306. https://doi.org/10.1108/OIR-11-2019-0350

IMD. (2024, April 5). *Cape Town—IMD business school for management and leadership courses*. https://www.imd.org/entity-profile/cape-town/

ISO. (2019). *ISO 21600:2019*. ISO. https://www.iso.org/standard/71225.html

Johnson, V. L., Woolridge, R. W., & Bell, J. R. (2021). The Impact of Consumer Confusion on Mobile Self-Checkout Adoption. *Journal of Computer Information Systems*, *61*(1), 76–86. https://doi.org/10.1080/08874417.2019.1566802

Karale, A. (2021). The Challenges of IoT Addressing Security, Ethics, Privacy, and Laws. *Internet of Things*, *15*, 100420. https://doi.org/10.1016/j.iot.2021.100420

Khan, I. H., & Javaid, Mohd. (2022). Role of Internet of Things (IoT) in Adoption of Industry 4.0. *Journal of Industrial Integration and Management*, *07*(04), 515–533. https://doi.org/10.1142/S2424862221500068

Kim, J., & Park, E. (2022). Understanding social resistance to determine the future of Internet of Things (IoT) services. *Behaviour & Information Technology*, *41*(3), 547–557. https://doi.org/10.1080/0144929X.2020.1827033

Kline, R. B. (2011). *Principles and practices structural equation modeling* (3rd ed.). The Guilford Press.

Krommenhoek, R. E., & Galpin, J. S. (2013). *Statistical research design analysis* [Course notes].

Lee, J., & Lee, K. (2021). Is the fourth industrial revolution a continuation of the third industrial revolution or something new under the sun? Analyzing technological regimes using US patent data. *Industrial and Corporate Change*, *30*(1), 137–159. https://doi.org/10.1093/icc/dtaa059

Manubabu, A., Lakshmi, M. V., Netish, V. P., & Padmanaban, A. (2022). Smart Thermal Jacket with Wearable Sensors using IoT. *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, 439–444. https://doi.org/10.1109/ICCMC53470.2022.9754104

Marikyan, D., Papagiannidis, S., & Alamanos, E. (2023). Cognitive Dissonance in Technology Adoption: A Study of Smart Home Users. *Information Systems Frontiers*, *25*(3), 1101–1123. https://doi.org/10.1007/s10796-020-10042-3

Martinez, A., Fitzroy, A., & Hogwart, A. (2024). Network Communication Security: Challenges and Solutions in the Digital Era. *International Journal of Cyber and IT Service Management*, *4*(1), Article 1. https://doi.org/10.34306/ijcitsm.v4i1.151

Moll, I. (2023). Why there is no technological revolution, let alone a 'Fourth Industrial Revolution'. *South African Journal of Science*, *119*(1/2). https://doi.org/10.17159/sajs.2023/12916

Mordor Intelligence. (2024). *IoT Market in South Africa—Companies, Size & Share*. https://www.mordorintelligence.com/industry-reports/south-africa-iot-market

Mweshi, G. K., & Sakyi, K. (2020). Application of sampling methods for the research design. *Archives of Business Research*, *8*(11), 180–193. https://doi.org/10.14738/abr.811.9042

Pal, D., Arpnikanondt, C., Funilkul, S., & Chutimaskul, W. (2020). The Adoption Analysis of Voice-Based Smart IoT Products. *IEEE Internet of Things Journal*, *7*(11), 10852–10867. https://doi.org/10.1109/JIOT.2020.2991791

Parasuraman, A. (2000). Technology Readiness Index (Tri): A Multiple-Item Scale to Measure Readiness to Embrace New Technologies. *Journal of Service Research*, *2*(4), 307–320. https://doi.org/10.1177/109467050024001

Parasuraman, A., & Colby, C. L. (2015). An Updated and Streamlined Technology Readiness Index: TRI 2.0. *Journal of Service Research*, *18*(1), 59–74. https://doi.org/10.1177/1094670514539730

Parliamentary Monitoring Group. (2023). *DPWI role in Smart City Projects to deal with the infrastructure requirements and service delivery needs of client departments; with Minister and Deputy Minister*. PMG. https://pmg.org.za/committee-meeting/37407/

Poongodi, T., Krishnamurthi, R., Indrakumari, R., Suresh, P., & Balusamy, B. (2020). Wearable Devices and IoT. In V. E. Balas, V. K. Solanki, R. Kumar, & Md. A. R. Ahad (Eds.), *A Handbook of Internet of Things in Biomedical and Cyber Physical System* (pp. 245–273). Springer International Publishing. https://doi.org/10.1007/978-3-030-23983-1_10

Priporas, C. V., Hussain, S., Khaneja, S., & Rahman, H. (2024). Technology distraction in Generation Z: The effects on consumer responses, sensory overload, and discomfort. *International Journal of Information Management*, *75*, 102751. https://doi.org/10.1016/j.ijinfomgt.2023.102751

Saunders, M., Lewis, P., Thornhill, A., & Bristow, A. (2015). Understanding research philosophy and approaches to theory development. In M. Saunders, P. Lewis, & A. Thornhill (Eds.), *Research Methods for Business Students* (pp. 122–161). Pearson Education. http://catalogue.pearsoned.co.uk/

Schumacker, R. E., & Lomax, R. G. (2004). *A beginner's guide to structural equation modeling* (2nd ed.). Lawrence Erbaum Associates.

Smith, K. T. (2020). Marketing via smart speakers: What should Alexa say? *Journal of Strategic Marketing*, *28*(4), 350–365. https://doi.org/10.1080/0965254X.2018.1541924

Somang, M., Fung So, K. K., & Miyoung, J. (2021). Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. In S. Kim & D. Wang (Eds.), *Future of tourism marketing* (1st ed., pp. 1–14). Routledge.

Spitzer, R. L., Endicott, J., & Robins, E. (1978). Research diagnostic criteria: Rationale and reliability. *Jama Psychiatry*, *35*(6), 773–782.

Tripathi, A., Sindhwani, N., Anand, R., & Dahiya, A. (2023). Role of IoT in Smart Homes and Smart Cities: Challenges, Benefits, and Applications. In N. Sindhwani, R. Anand, M. Niranjanamurthy, D. Chander Verma, & E. B. Valentina (Eds.), *IoT Based Smart Applications* (pp. 199–217). Springer International Publishing. https://doi.org/10.1007/978-3-031-04524-0_12

Truong, N. T., Dang-Pham, D., McClelland, R. J., & Nkhoma, M. (2020). Service innovation, customer satisfaction and behavioural intentions: A conceptual framework. *Journal of Hospitality and Tourism Technology*, *11*(3), 529–542. https://doi.org/10.1108/JHTT-02-2019-0030

Venkatesh, V., Morris, M. G., Davis, F. D., & Davis, G. B. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425-478.

Woodhead, R., Stephenson, P., & Morrey, D. (2018). Digital construction: From point solutions to IoT ecosystem. *Automation in Construction*, *93*, 35–46. https://doi.org/10.1016/j.autcon.2018.05.004